AFRL-IF-RS-TR-2005-328
Final Technical Report
September 2005

AN EXTENSIBLE MARKUP LANGUAGE (XML)-BASED SOFTWARE ARCHITECTURE ENABLING MODEL FUSION FOR THE BATTLE INFOSPHERE

University of Florida

AIR FORCE RESEARCH LABORATORY
INFORMATION DIRECTORATE
ROME RESEARCH SITE
ROME, NEW YORK

STINFO FINAL REPORT

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AFRL-IF-RS-TR-2005-328 has been reviewed and is approved for publication

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	SEPTEMBER 2005	Final Aug 01 – Mar 05

4. TITLE AND SUBTITLE
AN EXTENSIBLE MARKUP LANGUAGE (XML)-BASED SOFTWARE ARCHITECTURE ENABLING MODEL FUSION FOR THE BATTLE INFOSPHERE

5. FUNDING NUMBERS
C - F30602-01-1-0592
PE - 62702F
PR - 558B
TA - II
WU - 07

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8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Air Force Research Laboratory/IFSB
525 Brooks Road
Rome New York 13441-4505

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
AFRL-IF-RS-TR-2005-328

11. SUPPLEMENTARY NOTES

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12a. DISTRIBUTION / AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 Words)*

XML (eXtensible Markup Language) is the ubiquitous low-level language of the World Wide Web, and forms the primary structure for the emerging Semantic Web. The Semantic Web is the vision, and ongoing implementation, of how the web will transform over time to connect disparate pieces of knowledge, data, and resources. Our purpose in this contract was to create a foundation for the Semantic Web, suitable for deployment within the Air Force Infosphere project. The concept behind the Infosphere is one of rapid data and knowledge interchange, between physical objects, models, and computational processes. In our work, we created two XML schemas, defining two applications: MXL and DXL. MXL (Multimodeling eXchange Language) defines dynamic system models at a fairly high level of abstraction, and DXL (Dynamics eXchange Language) defines a low-level, block-oriented, language for a wide variety of simulation applications. With initial results in 2001, these two languages represented the first thorough implementations of XML in simulation, and they led the way to subsequent, higher level ontology studies.

14. SUBJECT TERMS
XML, Semantic Web, Modeling, Simulation

15. NUMBER OF PAGES
12

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

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ACKNOWLEDGMENTS

The PI of this contract would like to acknowledge a number of key people at the Rome Air Force Research Laboratory for their ongoing professional and personal collaboration relating to the general area of modeling and simulation: Alex Sisti, Dawn Trevisani, Steven Farr, Jason Moore, Barry McKinney, and Alex Sarnacki.

CONTRACTUAL ITEMS

The following items are specifically requested in the contract, and are addressed below:

1. *Accomplishments compared to goal objectives*: the accomplishments far exceed the original goal, which was to create an XML "presence" for use in the battle infosphere. We not only created two XML languages, schemas, and implementations around them, we also have extended this work to ontology definitions and use in the user interface. We constructed a comprehensive 3D dynamic model authoring environment, linking dynamic model with geometric model components.
2. *Reasons why established goals were not met if appropriate*: N/A.
3. *Cumulative list of publications*: see the *Results & Discussion* section.
4. *List of professional personnel*: Paul Fishwick (PI) and students. Students are listed toward the end of this report. Requested info for the PI is PhD Computer and Information Science, University of Pennsylvania, 1986. Thesis title: "Hierarchical Reasoning: Simulating Complex Processes over Multiple Levels of Abstraction".
5. *Papers presented at meetings*: See the comprehensive list under *Results & Discussion*.
6. *Consultive and advisory functions*: N/A.
7. *Inventions and Patents*: The software that we have constructed (SimPackJ, SimPackP, and RUBE) is open source.

INTRODUCTION

For the past four years, we have developed a software framework called RUBE. RUBE's purpose is to provide a modeler with a way in which to better integrate the phenomenon being modeled and the model itself. This integration is done using multiple visual modes of display, allowing the dynamic models, as well as the phenomena, to be displayed in 3D. Figure 1 displays the RUBE architecture. Our use of ontologies within the RUBE project is founded on two approaches: (1) schema definitions and XML files for model types and model files; and (2) an OWL representation of a sample air reconnaissance scene. We proceed with these in sequence.

RUBE begins its process with two types of interfaces: a 2D interface using the SodiPodi tool, and a 3D one using Blender, which is a tool for authoring and animating 3D scenes. The simulation analyst builds a scene to be simulated, and then builds dynamic models of that scene. The dynamic models are translated into MXL (Multimodel eXchange Language). MXL contains an ontology (or XML schema) defining certain model types and how they are defined. For example, a Finite State Machine contains an initial state, a set of states, and transitions. DXL (Dynamics eXchange Language) is a lower-level homogeneous block-model language capable of describing both synchronous and asynchronous execution of block networks. As such, DXL networks reflect behaviors such as those found in digital circuits as well as more loosely connected data flow networks. Both MXL and DXL are XML languages. Each has a schema, defining the language as an ontology. Returning to the process defined in Figure 1, a model is converted into MXL and then DXL, and finally into a target language such as Java or Javascript. This Javascript code is then reinserted into the scene. This is done by first exporting the Blender scene into an X3D (eXtensible 3D) file and then defining the Javascript in X3D script nodes. The final X3D scene file, intact with both geometric and dynamic properties, is then executed to yield the simulation. In addition to the work performed in RUBE, we have recently started to create an ontology that attempts to bring all knowledge about an application domain together. Figure 2 shows a network relating elements of a scene (JSTARS, F15, and UAV) with the geometry and dynamics of

these objects we have listed the defined styles that might be required during the formatting process. The idea here is that we can use RUBE to generate objects, that are then updated in the ontology. Moreover, we can add to the ontology manually, if necessary, to express the semantic relations. We are using OWL for expressing the network, and the Stanford Protégé tool for managing the links. There is a two-way connection between Blender and Protégé so that information can be entered in Protégé and then appear in Blender, and vice versa.

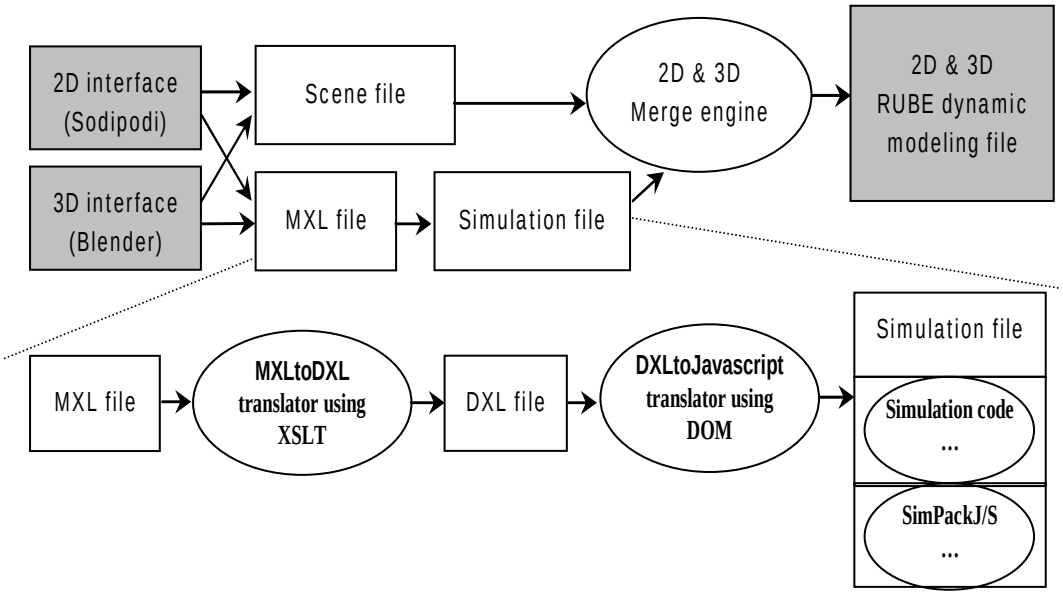

Figure 1: RUBE Framework, from Interface to Code Generation

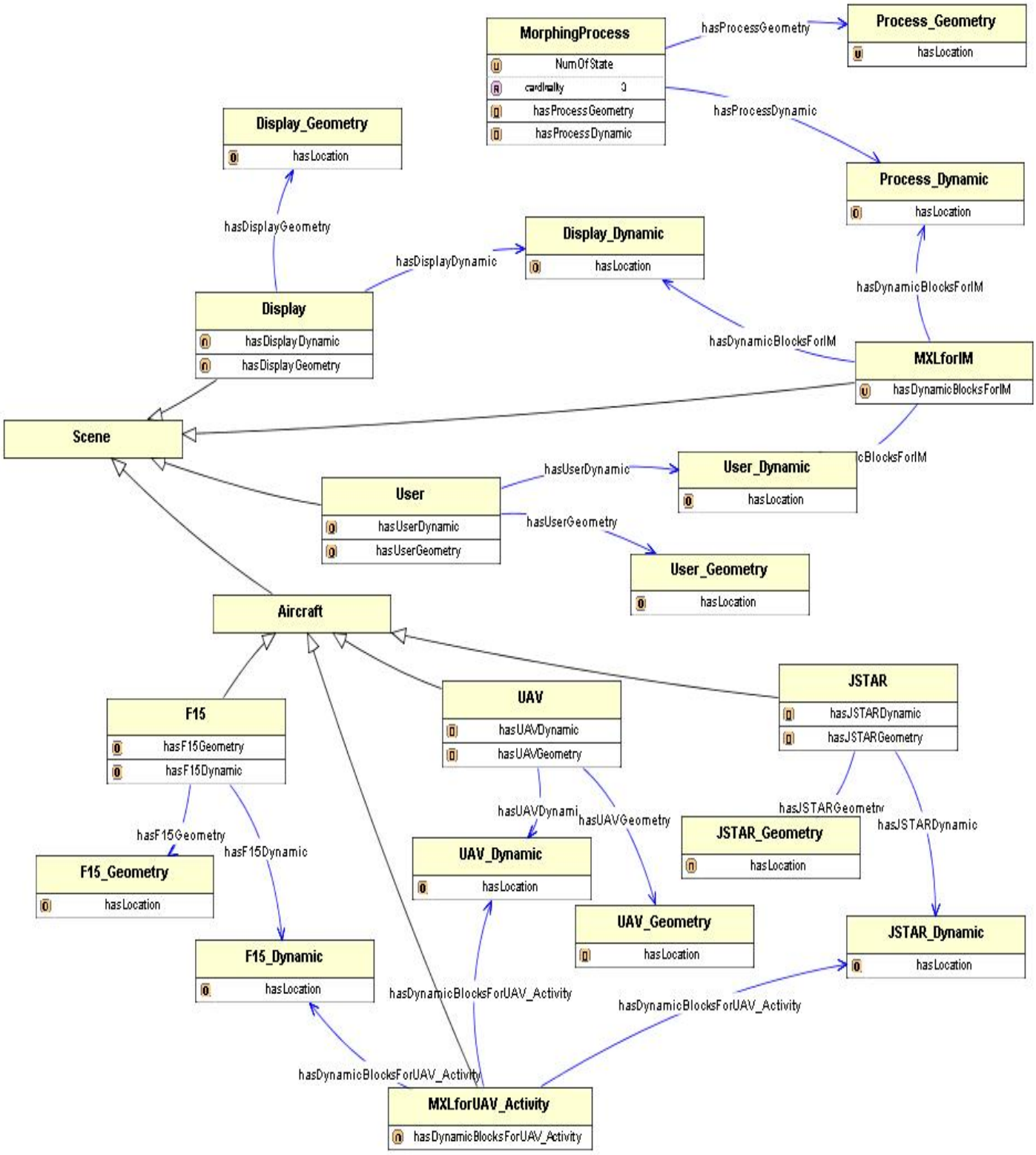

Figure 2: An Ontology Defining an Air Battle Scene with Reconnaissance and Surveillance Aircraft

RESULTS & DISCUSSION

This contract has resulted in a comprehensive set of published results which are defined below. We list the books completed, archival journal articles, and conference articles published. The contract also permitted three students to earn their doctoral degrees.

Multimedia Collections

- Paul A. Fishwick, Dynamic Systems Modeling, 3 CDs overviewing the nature of dynamic models, and why they are created.

Books

- Paul A. Fishwick and Benjamin Lok.``Proceedings of the 2005 Conference on Human-Computer Interface Advances for Modeling and Simulation (SIMCHI '05)", Society for Computer Modeling and Simulation International, 2005. 84pp.

- Paul A. Fishwick. ``Aesthetic Computing" MIT Press, sent to publisher, expected publication date - Fall 2005.

Archival Journal Articles

- John Hopkins and Paul A. Fishwick. ``Synthetic Human Agents for Modeling and Simulation", Proceedings of the IEEE in special issue ``Agent-Based Modeling and Simulation: Exploiting the Metaphor", February 2001, Volume 89, Number 2, pp. 131-147.

- John A. Miller, Paul A. Fishwick, Simon J.E. Taylor, Perakath Benjamin and Boleslaw Szymanski, ``Research and Commercial Opportunities in Web-Based Simulation" Simulation Practice and Theory (SPT), Special Issue on Web-Based Simulation, Vol. 9, No. 1-2 (October 2001), pp. 55-72, Elsevier Science.

- Paul A. Fishwick. ``Aesthetic Programming: Crafting Personalized Software", Leonardo, MIT Press, 2002, Volume 35, Number 4, pp. 383-390, 2002.

- Paul A. Fishwick. ``Aesthetic Computing: Making Artistic Mathematics and Software", Special Issue on Art and Programming, YLEM Journal (Artists Using Science & Technology), 10 (22), September - October 2002, pp. 6-11.

- John Hopkins and Paul A. Fishwick, ``Exploiting an Agent-Based Metaphor in Software Visualization using the rube System", Journal of Visual Languages and Computing, 14 (1), Feb. 2003, pp. 97-117.

- Taewoo Kim, Jinho Lee, and Paul Fishwick. ``A Two-Stage Modeling and Simulation Process for Web-Based Modeling and Simulation", ACM Transactions on Modeling and Computer Simulation, 12 (3), July 2002, pp. 230-248.

- Paul Fishwick. ``Aesthetic Computing Manifesto", Leonardo, MIT Press, 36 (4), August 2003, pp. 255-256.

- Paul A. Fishwick. ``Toward an Integrative Multimodeling Interface: A Human-Computer Interface Approach to Interrelating Model Structures", in the ``Grand Challenges" special issue of SCS Transactions on Modeling and Simulation, 80 (9): 421-432, September 2004.

- Hyunju Shim and Paul Fishwick. ``RUBE2D: A Web-Based Customizable 2D Modeling and Simulation System", International Journal of Simulation and Process Modeling (IJSPM), 1: 2-15. January 2004.

- Paul A. Fishwick, Stephan Diehl, Jane Prophet and Jonas Lowgren. ``Perspectives in Aesthetic Computing", Leonardo 38 (2): 133-141, MIT Press, 2005.

- Paul Fishwick. ``Nurturing Next-Generation Computer Scientists", IEEE Computer, December 2003, pp. 106-108.

- Paul Fishwick, Timothy Davis, and Jane Douglas. ``An Empirical Study of Aesthetic Computing", submitted to SCS Transactions on Modeling and Simulation, April 2005.

- Paul Fishwick. ``Enhancing Experiential and Subjective Qualities of Discrete Structure representations with Aesthetic Computing", accepted for Journal of Visual Languages and Computing (JVLC), May 2004.

- John A. Miller, Gregory T. Baramidze, Amit P. Sheth, and Paul A. Fishwick ``Ontologies for Modeling and Simulation: Initial Framework", submitted to ACM Transactions on Modeling and Computer Simulation, October 2004.

- Minho Park and Paul Fishwick. ``Ontology-based Customizable 3D Modeling for Simulation" submitted to SCS Transactions on Modeling and Simulation, February 2005.

Refereed Conference Articles

- Davis, Paul; Fishwick, Paul; Overstreet, Michael; Pegden, Dennis, ``Model Composability as a Research Investment" In Proceedings of the 2000 Winter Simulation Conference, Orlando, Florida, December 10-13, 2000. pp. 1585-1591.

- Fishwick, Paul. ``On Web-Based Models and Repositories", In Proceedings of Enabling Technology for Simulation Science, Part of SPIE AeroSense '01 Conference, Orlando, Florida, April 16-18. pp. 11-16.

- Dance, Linda and Fishwick, Paul. ``A Methodology for the 3D Modeling and Visualization of Concurrency Networks", In Proceedings of Enabling Technology for Simulation Science, Part of SPIE AeroSense '01 Conference, Orlando, Florida, April 16-18. pp. 152-163.

- Kim, Taewoo and Fishwick, Paul. ``Virtual Reality Modeling Language Templates for Dynamic Model Construction", In Proceedings of Enabling Technology for Simulation Science, Part of SPIE AeroSense '01 Conference, Orlando, Florida, April 16-18. pp. 144-151.

- Kim, Taewoo and Fishwick, Paul. ``A 3D-Based Visualization Framework for Dynamic Models", In Proceedings of the Web3D 2002 Symposium, Tempe, Arizona, February 2002, pp. 103-109.

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- Miller, J. A., Baramidze, Gregory T., Fishwick, Paul A. and Sheth, Amit P., ``Investigating Ontologies for Simulation Modeling: An Experiment with Generalized Semi-Markov Processes" Proceedings of the 37th Annual Simulation Symposium (ANSS'04), Arlington, Virginia, April 2004.

- Fishwick, P.A. and Miller, J. A. ``Ontologies for Modeling and Simulation: Issues and Approaches" Proceedings of the 2004 Winter Simulation Conference, Washington, DC, December 2004. pp. 259-264.

- Park, Minho and Fishwick, P. A. ``An Integrated Environment Blending Dynamic and Geometry Models" presented at the 2004 Artificial Intelligence, Simulation and Modeling in High Autonomy Systems (AISIM 2004), Jeju, Korea, October 2004, published in Springer LNAI 3397, Ed. Tag Gon Kim, pp. 574-584.